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# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for CDMA base station applications with frequencies from 1470 to 1510 MHz. Can be used in Class AB and Class C for all typical cellular base station modulations.

- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 600$  mA,  $P_{out} = 23$  Watts Avg.,  $f = 1507.5$  MHz, IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.  
 Power Gain — 19.5 dB  
 Drain Efficiency — 32%  
 Device Output Signal PAR — 6.2 dB @ 0.01% Probability on CCDF  
 ACPR @ 5 MHz Offset — -38 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 1490 MHz, 100 Watts CW Output Power
- Typical  $P_{out}$  @ 1 dB Compression Point  $\approx$  100 Watts CW

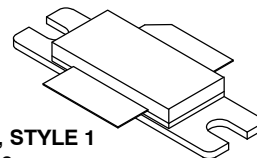
### Features

- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Optimized for Doherty Applications
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

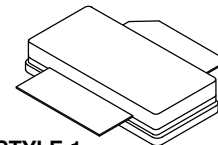
**MRF7S15100HR3**  
**MRF7S15100HSR3**

**1470-1510 MHz, 23 W AVG., 28 V**  
**SINGLE W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**

**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF7S1500HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF7S1500HSR3**



**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +65	Vdc
Gate-Source Voltage	$V_{GS}$	-6.0, +10	Vdc
Operating Voltage	$V_{DD}$	32, +0	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Case Operating Temperature	$T_C$	150	°C
Operating Junction Temperature (1,2)	$T_J$	225	°C
CW Operation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	CW	75 0.36	W W/°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 55 W CW Case Temperature 77°C, 23 W CW	$R_{\theta JC}$	0.65 0.74	°C/W

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	1C (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	IV (Minimum)

**Table 4. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Off Characteristics</b>					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DD} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{Adc}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 174\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.2	2	2.7	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 600\text{ mAdc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2	2.7	3.5	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.74\text{ Adc}$ )	$V_{DS(on)}$	0.1	0.2	0.3	Vdc

**Dynamic Characteristics (1)**

Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	0.6	—	pF
Output Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{oss}$	—	300	—	pF
Input Capacitance ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)	$C_{iss}$	—	176	—	pF

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 600\text{ mA}$ ,  $P_{out} = 23\text{ W Avg.}$ ,  $f = 1507.5\text{ MHz}$ , Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset.

Power Gain	$G_{ps}$	18	19.5	21	dB
Drain Efficiency	$\eta_D$	30	32	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.9	6.2	—	dB
Adjacent Channel Power Ratio	ACPR	—	-38	-35	dBc
Input Return Loss	IRL	—	-15	-8	dB

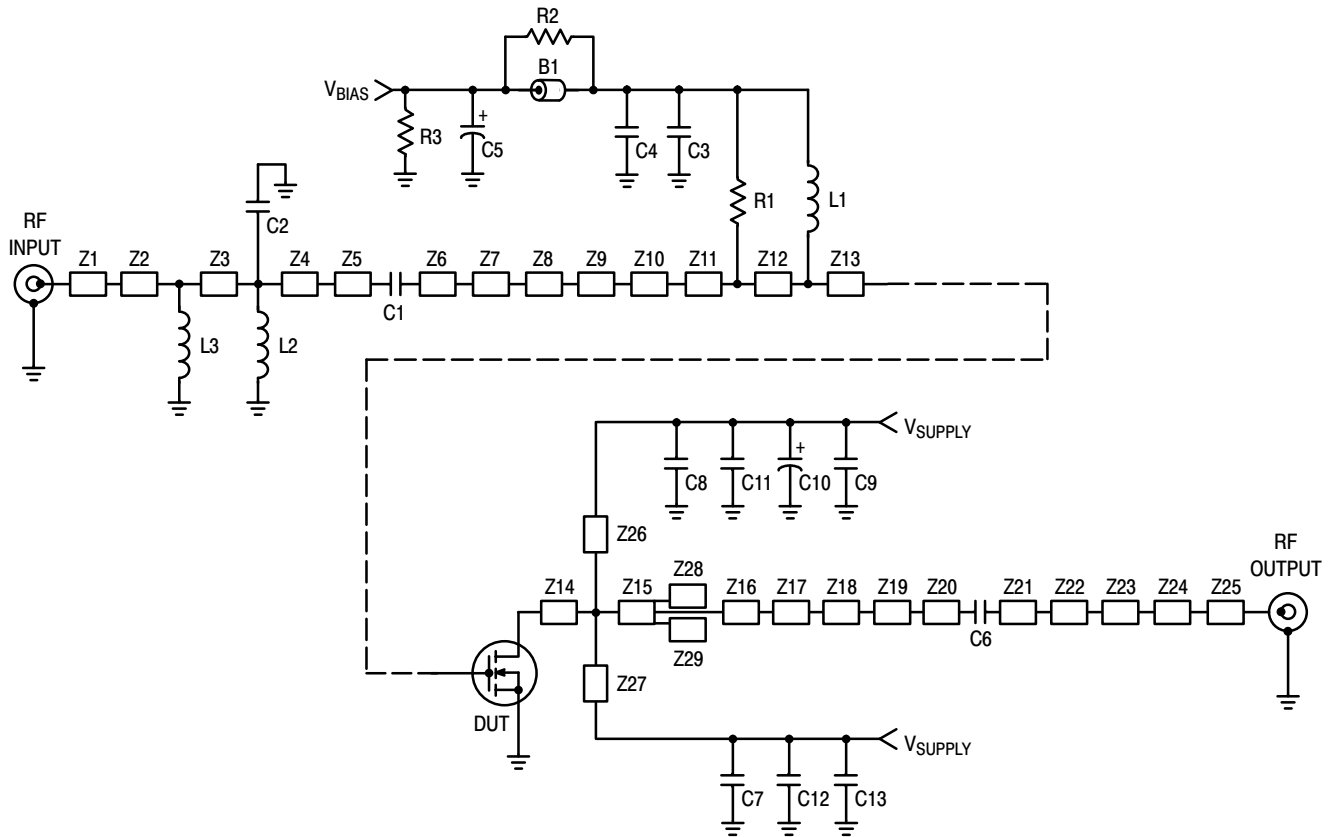
1. Part internally matched both on input and output.

(continued)



**Table 4. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 600\text{ mA}$ , 1470-1510 MHz Bandwidth					
$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	100	—	W
IMD Symmetry @ 90 W PEP, $P_{out}$ where IMD Third Order Intermodulation $\cong 30\text{ dBc}$ (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands > 2 dB)	IMD <sub>sym</sub>	—	40	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW <sub>res</sub>	—	70	—	MHz
Gain Flatness in 40 MHz Bandwidth @ $P_{out} = 23\text{ W Avg.}$	G <sub>F</sub>	—	0.2	—	dB
Average Deviation from Linear Phase in 40 MHz Bandwidth @ $P_{out} = 100\text{ W CW}$	$\Phi$	—	4.5	—	°
Average Group Delay @ $P_{out} = 100\text{ W CW}$ , $f = 1490\text{ MHz}$	Delay	—	1.9	—	ns
Part-to-Part Insertion Phase Variation @ $P_{out} = 100\text{ W CW}$ , $f = 1490\text{ MHz}$ , Six Sigma Window	$\Delta\Phi$	—	23	—	°
Gain Variation over Temperature (-30°C to +85°C)	$\Delta G$	—	0.010	—	dB/°C
Output Power Variation over Temperature (-30°C to +85°C)	$\Delta P_{1dB}$	—	0.007	—	W/°C



Z1	0.084" x 0.078" Microstrip	Z15	1.330" x 0.538" Microstrip
Z2	0.149" x 0.153" Microstrip	Z16	0.270" x 0.280" Microstrip
Z3	0.149" x 0.303" Microstrip	Z17	0.187" x 0.150" Microstrip
Z4	0.149" x 0.065" Microstrip	Z18	0.084" x 0.042" Microstrip
Z5	0.084" x 0.146" Microstrip	Z19	0.184" x 0.292" Microstrip
Z6	0.084" x 0.104" Microstrip	Z20	0.084" x 0.066" Microstrip
Z7	0.218" x 0.080" Microstrip	Z21	0.886" x 0.194" Microstrip
Z8	0.084" x 0.206" Microstrip	Z22	0.300" x 0.084" Microstrip
Z9	0.224" x 0.085" Microstrip	Z23	0.084" x 0.215" Microstrip
Z10	0.084" x 0.369" Microstrip	Z24	0.221" x 0.075" Microstrip
Z11	1.288" x 0.206" Microstrip	Z25	0.084" x 0.175" Microstrip
Z12	1.288" x 0.144" Microstrip	Z26, Z27	0.200" x 0.525" Microstrip
Z13	1.288" x 0.369" Microstrip	Z28, Z29	0.235" x 0.102" Microstrip
Z14	1.330" x 0.112" Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$

**Figure 1. MRF7S15100HR3(HSR3) Test Circuit Schematic**

**Table 5. MRF7S15100HR3(HSR3) Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
B1	Short Ferrite Bead	2743019447	Fair-Rite
C1, C6, C7, C8	15 pF Chip Capacitors	ATC100B150JT500XT	ATC
C2	0.5 pF Chip Capacitor	ATC100B0R5BT500XT	ATC
C3	10 pF Chip Capacitor	ATC100B100JT500XT	ATC
C4, C9, C13	6.8 $\mu$ F, 50 V Chip Capacitors	C4532JB1H685MT	TDK
C5, C10	100 $\mu$ F, 50 V Electrolytic Capacitors	222215371101	Vishay
C11, C12	2.2 $\mu$ F, 50 V Chip Capacitors	C3225JB2A225MT	TDK
L1, L2, L3	7.15 nH Inductors	1606-TLC	Coilcraft
R1, R2	100 $\Omega$ , 1/4 W Chip Resistors	CRCW12061000FKEA	Vishay
R3	10 K $\Omega$ , 1/4 W Chip Resistor	CRCW12061002FKEA	Vishay

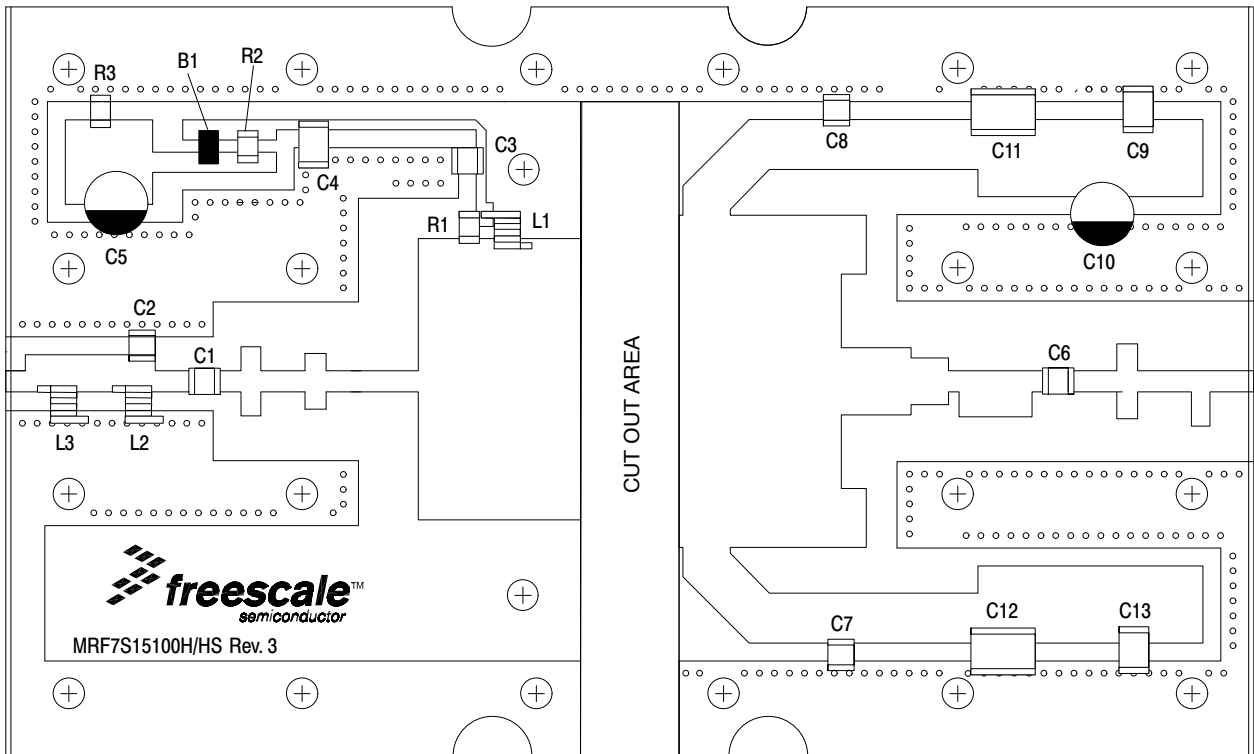
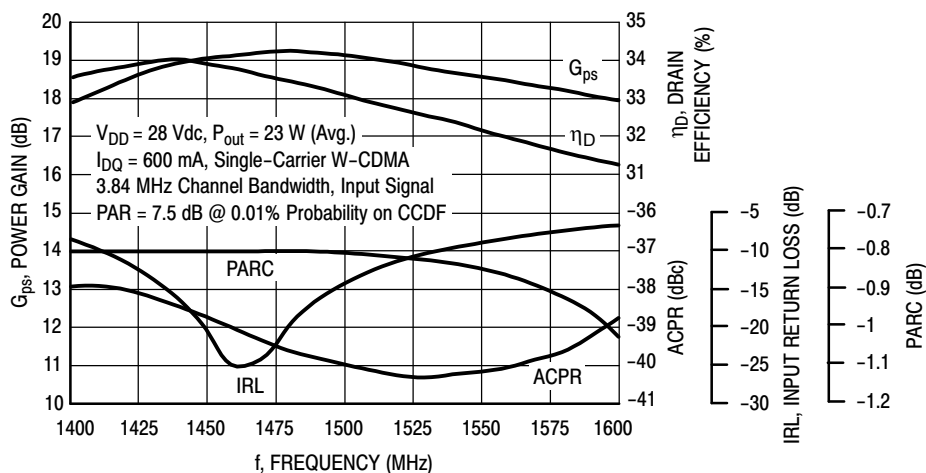
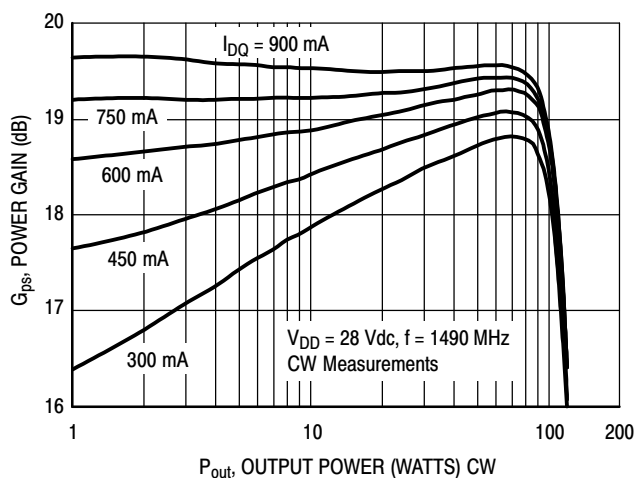


Figure 2. MRF7S15100HR3(HSR3) Test Circuit Component Layout

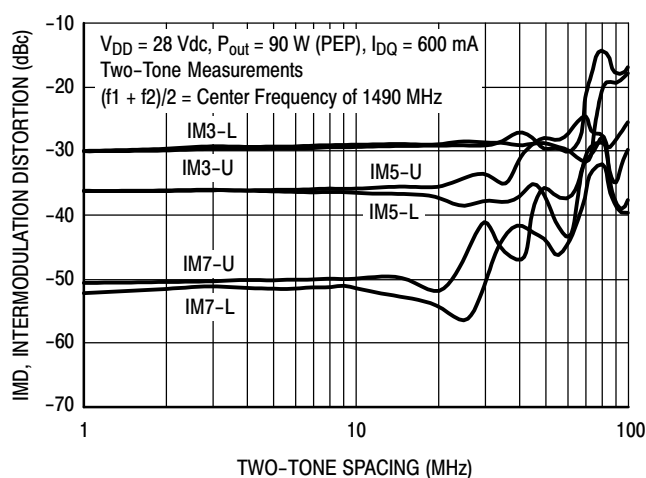
### TYPICAL CHARACTERISTICS



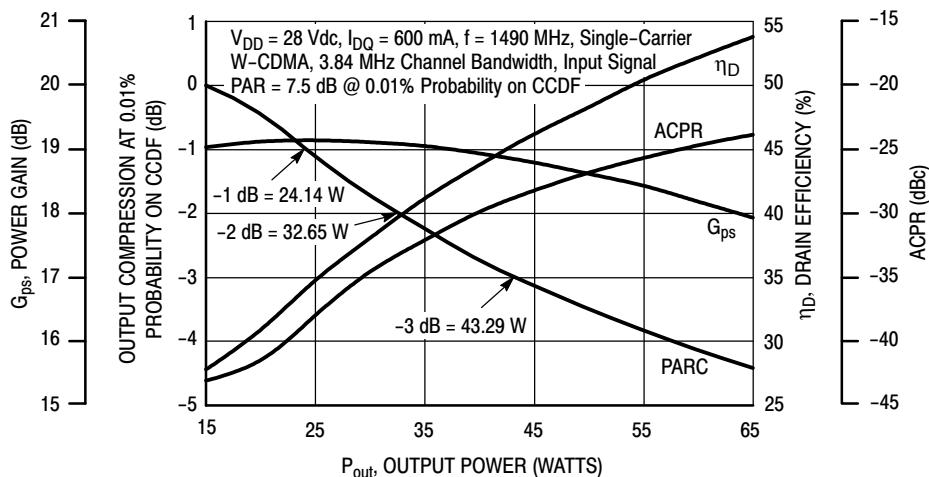
**Figure 3. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 23$  Watts Avg.**



**Figure 4. CW Power Gain versus Output Power**

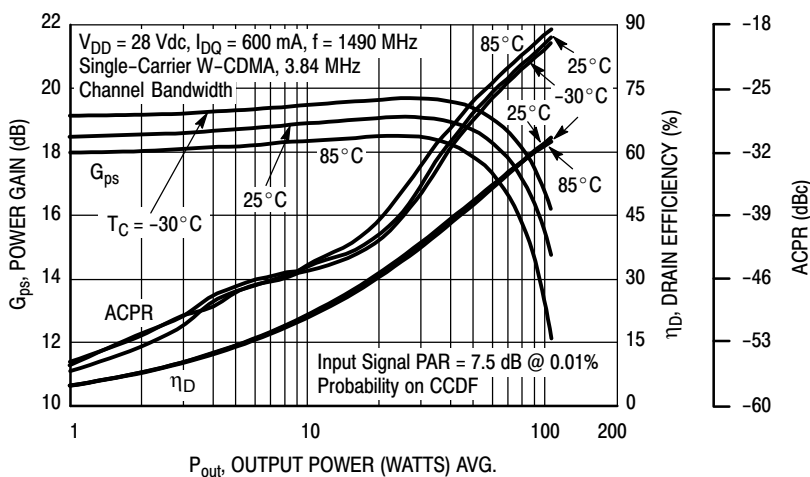


**Figure 5. Intermodulation Distortion Products versus Tone Spacing**

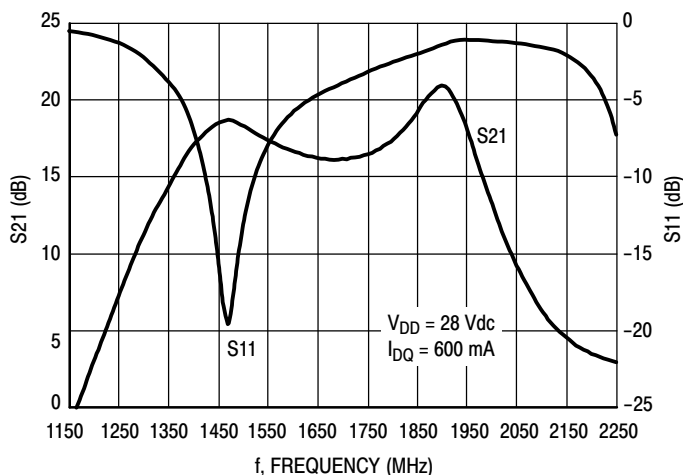


**Figure 6. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

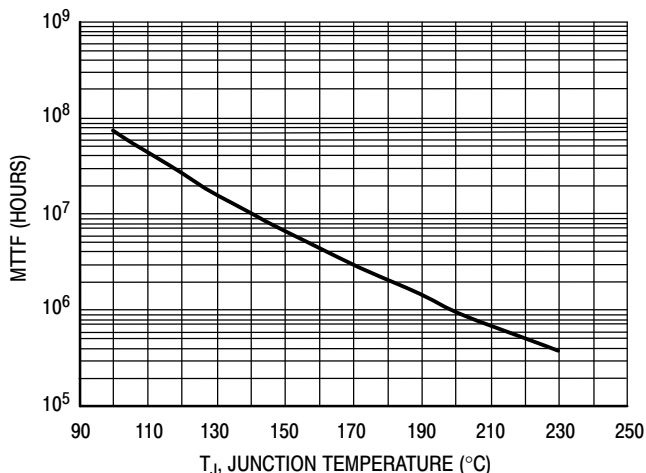
### TYPICAL CHARACTERISTICS



**Figure 7. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**



**Figure 8. Broadband Frequency Response**



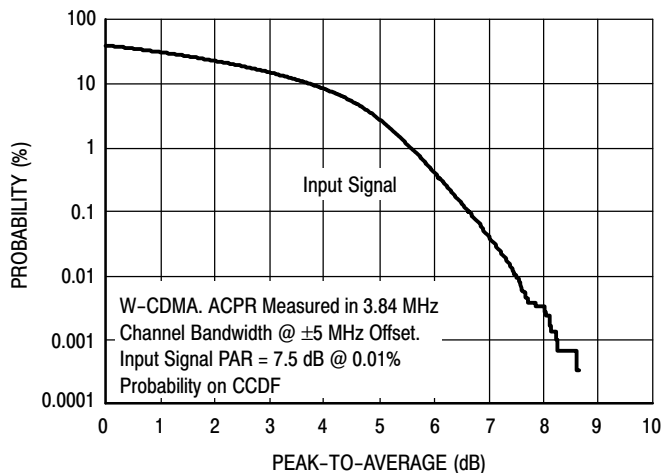
This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 23$  W Avg., and  $\eta_D = 32\%$ .

MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

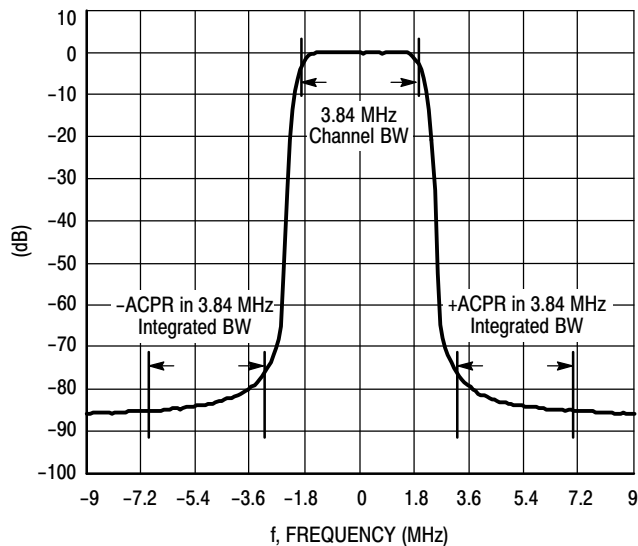
**Figure 9. MTTF versus Junction Temperature**



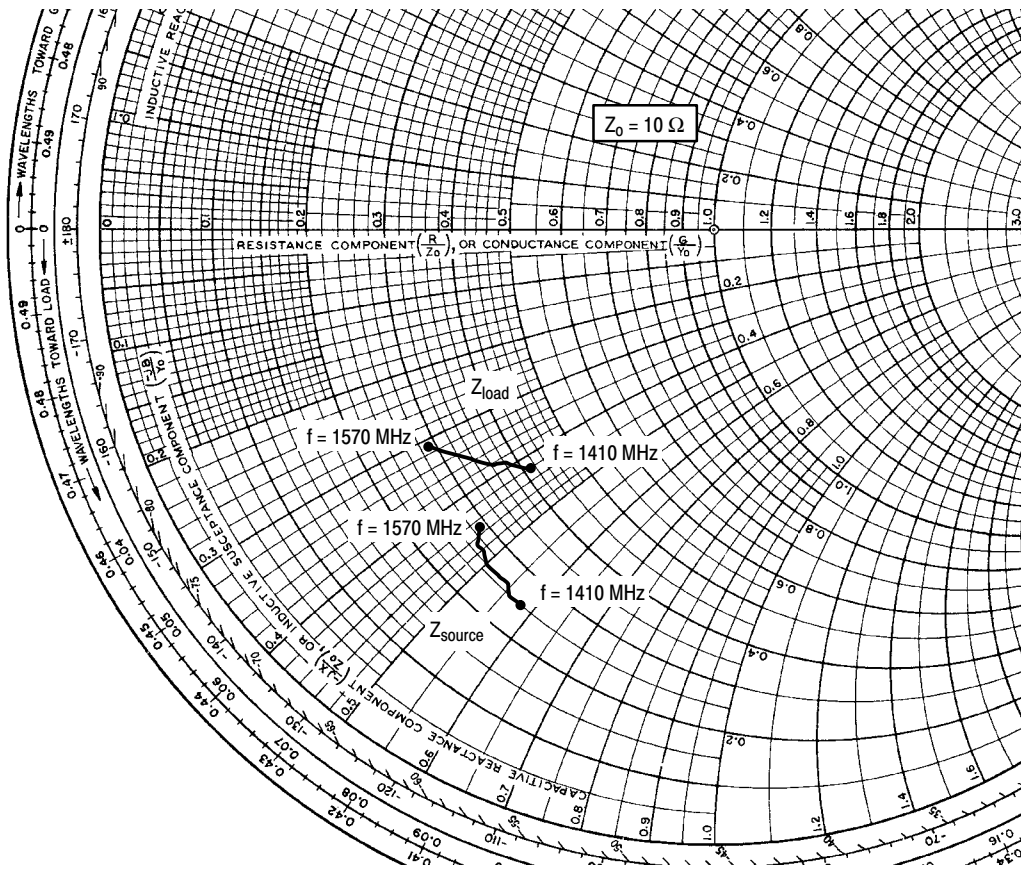
### W-CDMA TEST SIGNAL



**Figure 10. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal**



**Figure 11. Single-Carrier W-CDMA Spectrum**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 600 \text{ mA}$ ,  $P_{out} = 23 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
1410	2.51 - j5.82	4.12 - j4.20
1430	2.53 - j5.58	3.95 - j4.07
1450	2.55 - j5.36	3.78 - j3.94
1470	2.58 - j5.15	3.61 - j3.80
1490	2.62 - j4.97	3.45 - j3.65
1510	2.67 - j4.81	3.30 - j3.51
1530	2.73 - j4.68	3.15 - j3.37
1550	2.79 - j4.57	3.00 - j3.22
1570	2.85 - j4.49	2.87 - j3.06

$Z_{source}$  = Test circuit impedance as measured from gate to ground.

$Z_{load}$  = Test circuit impedance as measured from drain to ground.

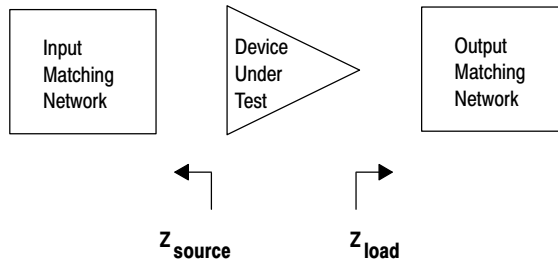
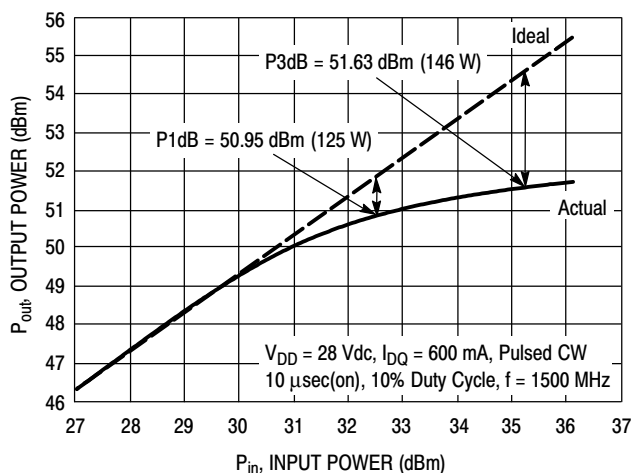


Figure 12. Series Equivalent Source and Load Impedance

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS



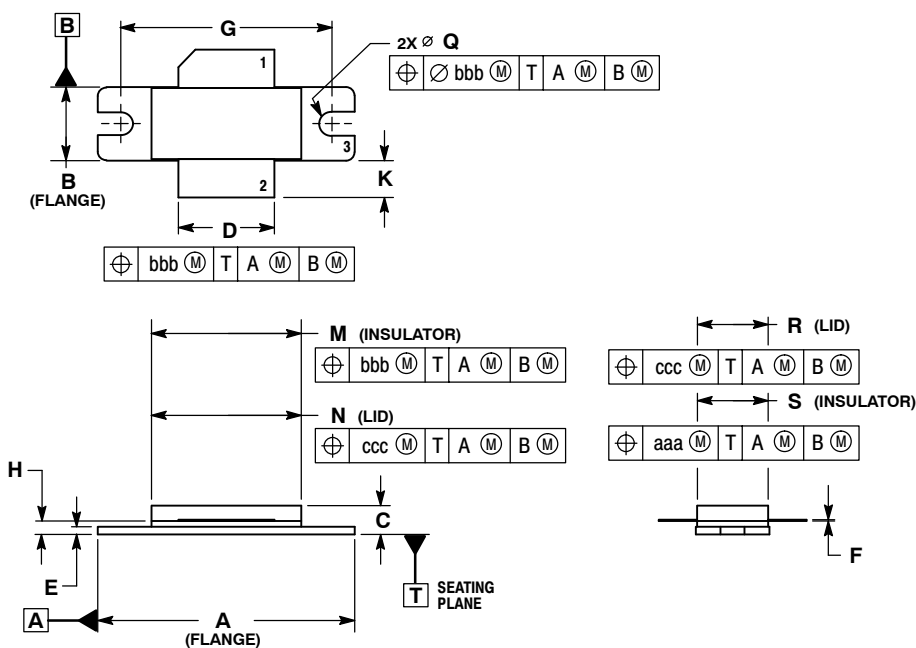
NOTE: Load Pull Test Fixture Tuned for Peak P1dB Output Power @ 28 V

Test Impedances per Compression Level

	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
P1dB	$2.02 + j6.21$	$2.00 - j3.65$

Figure 13. Pulsed CW Output Power versus Input Power @ 28 V

## PACKAGE DIMENSIONS

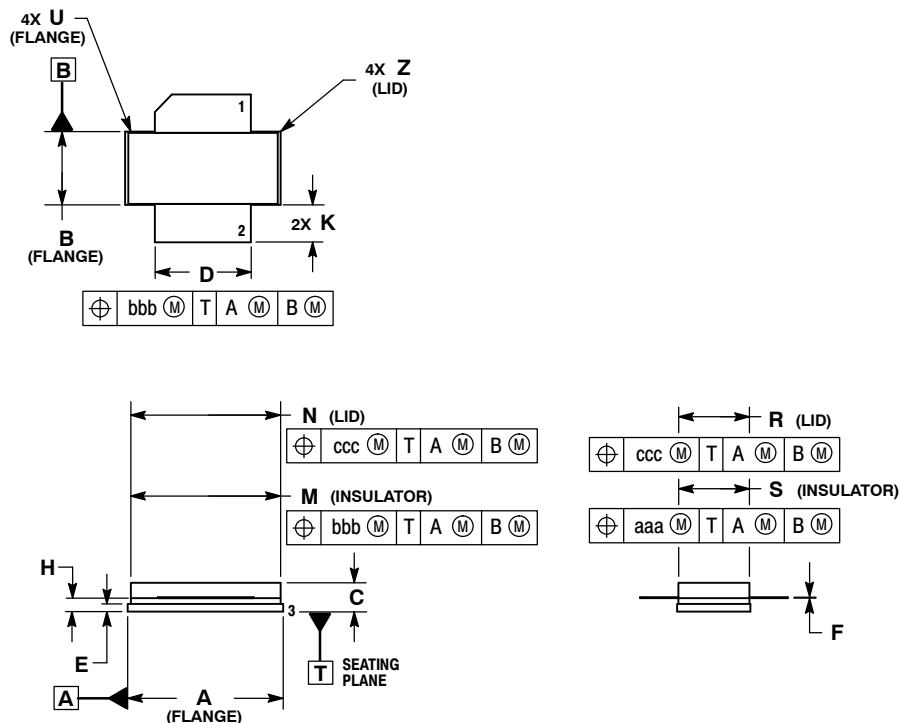


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
  2. CONTROLLING DIMENSION: INCH.
  3. DELETED
  4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
G	1.100 BSC		27.94 BSC	
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.774	0.786	19.66	19.96
N	0.772	0.788	19.60	20.00
Q	∅.118	∅.138	∅3.00	∅3.51
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
aaa	0.005 REF		0.127 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	

- STYLE 1:  
 PIN 1. DRAIN  
 2. GATE  
 3. SOURCE

**CASE 465-06  
 ISSUE G  
 NI-780  
 MRF7S15100HR3**



- NOTES:
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  2. CONTROLLING DIMENSION: INCH.
  3. DELETED
  4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.805	0.815	20.45	20.70
B	0.380	0.390	9.65	9.91
C	0.125	0.170	3.18	4.32
D	0.495	0.505	12.57	12.83
E	0.035	0.045	0.89	1.14
F	0.003	0.006	0.08	0.15
H	0.057	0.067	1.45	1.70
K	0.170	0.210	4.32	5.33
M	0.774	0.786	19.61	20.02
N	0.772	0.788	19.61	20.02
R	0.365	0.375	9.27	9.53
S	0.365	0.375	9.27	9.52
U	---	0.040	---	1.02
Z	---	0.030	---	0.76
aaa	0.005 REF		0.127 REF	
bbb	0.010 REF		0.254 REF	
ccc	0.015 REF		0.381 REF	

- STYLE 1:  
 PIN 1. DRAIN  
 2. GATE  
 5. SOURCE

**CASE 465A-06  
 ISSUE H  
 NI-780S  
 MRF7S15100HSR3**

Refer to the following documents to aid your design process.

**Application Notes**

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

**Engineering Bulletins**

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

**Software**

- Electromigration MTTF Calculator
- RF High Power Model

For Software and Tools, do a Part Number search at <http://www.freescale.com>, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

**REVISION HISTORY**

The following table summarizes revisions to this document.

Revision	Date	Description
0	July 2008	<ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>
1	Feb. 2009	<ul style="list-style-type: none"> <li>• Added Fig. 9, MTTF versus Junction Temperature, p. 7</li> </ul>
2	June 2009	<ul style="list-style-type: none"> <li>• Added Maximum CW limit and temperature derating factor to the Maximum Ratings table, p. 1</li> <li>• Fig. 10, CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal and Fig. 11, Single-Carrier W-CDMA Spectrum updated to show the undistorted input test signal, p. 8</li> <li>• Added Electromigration MTTF Calculator and RF High Power Model availability to Product Documentation, Tools and Software, p. 12</li> </ul>



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